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**CANAIGRE TANNIN  
HIGH-YIELDING STRAINS, SEASONAL VARIATION,  
AND GERM PLASM BANK**

**ABSTRACT**

The canaigre projects in the United States Department of Agriculture have been discontinued. It appeared desirable to summarize recent investigations and newer knowledge of special interest. The development of high-tannin, high-purity strains of canaigre, the changes in the composition of the roots during the growing season, and the preservation of canaigre in living germ plasm banks will be discussed.†



**INTRODUCTION**

The United States has become almost completely dependent on foreign sources for its supply of tanning materials. Before and during World War II there was concern that this supply might be cut off. The war did reduce the importation of tanning materials. This led to a military interest in national self-sufficiency. Following the war, imported vegetable tanning materials were stockpiled.

\*Eastern Utilization Research and Development Division, Agricultural Research Service, United States Department of Agriculture.

†Supplementary material to this article has been deposited with the ADI Auxiliary Project, Photoduplication Service, Library of Congress, Washington 25, D. C. This material, in the form of tables, contains information on hill number, pedigree, origin, plant characteristics, tannin content, and extract purity. Maps are included showing the plantings of 212 varieties and four bulk plantings in three locations in Tonto National Forest, Arizona. Directions are included for reaching these locations. A copy may be secured from the Chief, Photoduplication Service, Library of Congress, if authorized by the U. S. Department of Agriculture.

Material supplementary to this article has been deposited as Document number 7968 with the ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D. C. A copy may be secured by citing the Document number and by remitting \$3.75 for photoprints, or \$2.00 for 35mm. microfilm. Advance payment is required. Make checks or money orders payable to: Chief, Photoduplication Service, Library of Congress.

shoes were studied over a period of 14 months. In the light of this wear test, it was concluded that canaigre extract would be an acceptable domestic substitute for imported vegetable tanning materials.

#### HIGH-TANNIN, HIGH-PURITY STRAINS OF CANAIGRE

The objective of the canaigre breeding program in the Crops Research Division has been to produce high-yielding varieties which are high in tannin content and extract purity and which have both disease and insect resistance.

From time to time canaigre samples have been collected throughout the arid and semiarid regions of Western United States and Northern Mexico for use in

TABLE I  
TANNIN CONTENT AND EXTRACT PURITY OF CANAIGRE  
GROWN UNDER IRRIGATION AT MESA, ARIZONA

Original source of plants	Tannin Content (Dry- Weight Basis) %	Extract Purity* %
Salt River (Mesa, Arizona)	35.5	62.7
" " " "	37.7	63.6
" " " "	32.5	64.1
" " " "	37.5	66.0
" " " "	34.3	63.2
Sacaton, Arizona	35.3	62.8
Tucson, Arizona	33.4	65.2
" "	39.3	66.7
Higley, Arizona	29.3	56.3
Deming, New Mexico	30.5	57.2
Whitewater, Colorado	4.7	12.6
Bedrock, Colorado	20.4	44.6
Colton, California	30.6	57.6
Little Rock, California	34.4	62.4
Overton, Nevada	24.7	50.7
Bluff, Utah	18.0	48.5
Hite, Utah	30.0	54.8
Balmorhea, Texas	13.9	40.9
Sierra Blanca, Texas	21.8	49.8
Van Horn, Texas	11.8	31.3
Sonora, Mexico	40.8	69.8
" "	30.6	66.1
" "	30.7	61.2
" "	36.6	69.5
" "	39.8	70.2
" "	41.9	72.4

\*Extract purity is tannin divided by soluble extractives times 100.

Canaigre, *Rumex hymenosepalus* Torr, a plant indigenous to the southwestern part of the United States, had been used by the Indians and Mexicans for tanning for centuries (1). Late in the 19th century and early in this century there was considerable interest in canaigre as a source of tannin. From 1880 to 1910 more than 50 publications appeared dealing with its growing and harvesting, its use in making tanning extract, and its possible future as a tanning agent (2). A canaigre extract plant operated in New Mexico for a few years utilizing wild roots. German tanners became interested in canaigre, and both sliced, dried roots and extract were shipped to Germany for use in leathermaking. For a time, there was at least one specialty leather tannery in this country using canaigre in its tanning process.

This interest was justified because canaigre is high in tannin, containing 25-40% on a dry basis. It was found growing wild on arid land. It can be grown as a 1- or 2-year crop under irrigation on land with a reasonable level of fertility. Practically all other domestic vegetable tannin sources depend upon trees which require many years to grow.

Canaigre research was initiated in the Department of Agriculture in 1937. Extraction and tanning tests were completed in 1955. Analyses were continued for the Crops Research Division until 1963. As a result of this research much has been learned about the cultivation and breeding of canaigre and its use as a tanning material. However, the problems encountered in its cultivation and harvesting, and in the production of tanning extracts, have combined with a decrease in the cost of imported vegetable tannins and a decrease in heavy leather production to make the development of canaigre as a tanning material economically unsound. The development of a synthetic substitute for vegetable tannins has also reduced the need for a domestic source of tannins.

During this period of research, experimental plots of canaigre were grown in several states, and methods of propagation, cultivation, shredding, and field drying (3,4) as well as yields, selection of strains, and harvesting procedures (4) have been investigated by the Crops Research Division as cooperators in tanning-material development projects. New methods of analysis, drying, extraction, and extract purity improvement were developed (5-15). Satisfactory leathers were made from canaigre extracts prepared in various ways (16).

Two significant wear tests of canaigre-tanned leathers have been conducted. In the first of these, the postman's wear test, a blend of 50% canaigre, 25% chestnut, and 25% sulfited quebracho was used as the tanning liquor (17). Results obtained in this test indicated that the wear of leather tanned with a canaigre blend is equal to that of regular production.

Subsequently, the Quartermaster Research and Engineering Command of the U. S. Army conducted a wear test on leather which had been tanned with canaigre extract alone (18). This leather was used as the insoles and outsoles on low-quarter shoes for troops on garrison duty. Service characteristics of these

TABLE III  
EFFECT OF CANAIGRE ROOT COMPOSITION ON QUALITY OF  
TANNIN EXTRACT PRODUCED

Root Source		Roots		Purity* of Extracted Tannin	
		Tannin %	Purity* %	Before Fermentation %	After Fermentation %
Salt River	1953	35.4	62.4	52.9	64.0
Wilcox	1950	28.9	65.7	55.0	61.5
Wilcox	1953	25.8	58.8	47.1	54.5
Wilcox	1953	27.5	57.4	44.1	51.5

\*Purity is tannin divided by soluble extractives times 100.

In Table IV are listed four strains selected from the breeding program: T43-1S<sub>i</sub>, T43 2S<sub>i</sub>, (SRXY)-7, and 70-17. These represent varieties high in tannin content and extract purity. Two of them, T43 2S<sub>i</sub> and (SRXY)-7, have a good to high yield. These strains have been grown for two or more years, and the data indicate that the high tannin and extract purity can be maintained.

The other varieties listed in Table IV were selected from the wild. They have been grown for three or more years, and the data indicate that their tannin content and extract purity can be maintained under favorable cultural conditions.

The canaigre pilot plant extraction work was completed at this laboratory\* in 1955 before varieties containing 40% tannin had been developed. Had some of these high-tannin, high-extract purity canaigre strains been available, even better canaigre tannin extracts could have been produced.

#### CHANGES OCCURRING IN CHEMICAL CONSTITUTION AND GROWTH

During 1961 a detailed study of the changes occurring in canaigre growth and chemical constitution was conducted on four of the best vegetative lines: SR 28, SR 41, A3-203, and A25-135. Previous experiments had been concerned with a single variety. Growth progress was measured and recorded at 2-week intervals. Samples for tannin analysis were collected weekly until the top growth declined, from February 6 through May 15, 1961, and then at 2-week intervals until July 24. The harvested samples were shredded and sent to this laboratory\* for analysis.

Upon arrival, the samples were ground to pass a 3-mm. screen, and aliquots were extracted in a Reed-Churchill† extractor with 50% aqueous acetone at 60°C. The acetone was distilled off, the water solution was diluted to the proper

\*Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

†Mention of brand or firm names does not constitute an endorsement by the Department of Agriculture over others of a similar nature not mentioned.

breeding and cultural studies. The tannin and extract purity varied widely. Data of a few wild collections grown under uniformly irrigated conditions are presented in Table I (4). The tannin content of these samples ranges from 4.7% to 41.9%. Samples from the Salt River region near Mesa, Arizona, and the Sacaton and Tucson, Arizona, areas have proven to be some of the best collected. The samples from Sonora, Mexico, were collected in 1960. Some of these appear to be high-quality roots.

Selection within progenies from various geographic sources has provided strains with superior yield, tannin content, and extract purity (4). The data given in Table II indicate the progress made in this breeding and selection program. A number of canaigre strains have been produced which contain at least 40% tannin and which have an extract purity of 70 or above. A large number of strains containing 37–39% tannin with extract purities of 65–74% have been produced.

TABLE II  
PROGRESS IN DEVELOPING HIGH-TANNIN-  
PRODUCING STRAINS OF CANAIGRE

Year	Total No. Strains	Number of Strains with	
		Tannin Over 40%	Extract Purity† Over 70%
1950	137	0	0
1954	467	5 (0)*	1
1956	431	5 (3)	4
1957	353	11 (6)	8
1958	419	13 (7)	31
1959	227	15 (9)	30

\*Number of strains containing over 40% tannin that gave extracts with purity over 70.

†Extract purity is tannin divided by soluble extractives times 100.

Extract purity is the ratio of tannin to soluble extractives, expressed as percent, but on a different basis than the percent of tannin, which is based on the weight of the moisture-free root. Purity is important because it indicates, to a large extent, the ease of extraction and clarification as well as the tanning properties of the extract. When work began on the extraction of canaigre, a typical sample had a tannin content of 30% or less and an extract purity of 45–55%. Only a small percentage of samples had a higher tannin content or extract purity. Table III illustrates the effect of canaigre root composition on the quality of the tannin extract produced. These extracts were produced by a continuous countercurrent water extraction followed by a fermentation process to remove sugars. It is evident that high-tannin, high-purity varieties will produce tannin extracts with the best purity.

TABLE V  
ANALYTICAL DATA\* ON 4 VARIETIES OF CANAIGRE ROOTS HARVESTED  
AT 1- OR 2-WEEK INTERVALS FROM EARLY FEBRUARY THROUGH JULY 1961

Harvest Date	A3-203					A25-135					SR 28					SR 41				
	Hill Wt.† g.	Dry Matter† %	Tannin Content† %	Extract Purity** %	Hill Wt. g.	Dry Matter %	Tannin Content %	Extract Purity %	Hill Wt. g.	Dry Matter %	Tannin Content %	Extract Purity %	Hill Wt. g.	Dry Matter %	Tannin Content %	Extract Purity %	Hill Wt. g.	Dry Matter %	Tannin Content %	Extract Purity %
2/5	104	19.0	12.9	31.1	18	20.5	17.7	41.5	69	21.3	17.9	39.9	66	16.8	17.5	40.7				
2/13	—	—	24.1	42.5	—	—	21.9	42.3	—	—	24.7	43.0	—	—	24.3	43.1				
2/20	90	18.2	22.0	50.0	36	21.7	19.8	50.2	106	23.3	22.3	50.7	110	22.3	22.5	49.2				
2/27	—	—	23.1	49.0	—	—	21.2	49.6	—	—	21.6	48.4	—	—	22.1	50.0				
3/6	177	24.7	23.8	51.9	68	21.0	23.8	59.2	134	24.0	23.0	54.1	184	24.6	24.7	54.6				
3/13	—	—	24.7	54.4	—	—	28.0	65.0	—	—	25.9	59.1	—	—	24.7	54.2				
3/20	292	23.8	26.7	57.7	186	25.2	28.5	65.0	230	25.6	27.6	62.0	309	26.6	28.2	60.6				
3/27	—	—	29.2	64.1	—	—	30.4	68.0	—	—	29.5	62.9	—	—	31.3	65.0				
4/3	475	26.4	28.5	61.4	206	28.4	29.6	67.4	381	27.5	29.9	65.1	474	25.5	30.5	65.9				
4/10	—	—	29.6	63.0	—	—	31.0	66.2	—	—	29.7	63.7	—	—	30.8	64.7				
4/17	765	30.3	30.8	63.7	339	29.2	32.4	67.9	546	29.4	31.6	67.0	534	28.5	32.3	66.2				
4/24	—	—	32.7	66.0	—	—	33.3	68.2	—	—	30.1	64.1	—	—	30.5	65.2				
5/1	839	29.0	32.0	67.3	292	29.4	33.0	68.6	548	30.4	33.0	69.1	582	29.4	32.9	67.5				
5/8	—	—	32.2	67.5	—	—	33.4	69.1	—	—	32.4	69.2	—	—	32.7	67.7				
5/15	739	29.0	32.4	68.7	381	31.4	34.1	71.0	622	31.0	32.3	67.6	649	31.4	33.0	69.1				
5/29	686	30.7	33.6	69.2	489	28.1	33.7	71.3	699	31.0	35.8	72.4	739	29.6	34.3	70.8				
6/12	754	26.5	33.6	68.7	514	30.4	34.5	70.6	883	28.0	35.6	71.9	901	26.9	35.5	70.2				
6/26	817	28.2	34.3	66.9	352	30.4	34.7	66.4	882	27.9	35.8	70.1	836	29.0	36.3	69.0				
7/10	756	27.3	34.5	67.1	805	26.5	35.9	66.4	675	26.1	35.5	67.9	805	26.5	36.2	67.7				
7/24	744	26.1	35.0	65.2	615	29.4	36.3	64.1	762	28.8	37.1	67.0	838	28.0	36.8	65.1				

\*All determinations were conducted on the current growth season's roots only.  
†These data were obtained only at 2-week intervals.  
‡The tannin content and extract purity were calculated on the moisture-free basis for all four canaigre varieties.  
\*\*Extract purity is tannin divided by soluble extractives times 100.

TABLE IV  
SOME CANAIGRE VARIETIES GROWN AND ANALYZED FOR TWO OR MORE YEARS

SOME CANAIGRE VARIETIES GROWN AND ANALYZED																	
Sample	Origin and Date of Collection	1952		1953		1954		1957		1958		1959		1960		1961	
		Tan- nin %	Ex- tract* Purity %	Tan- nin %	Ex- tract* Purity %	Tan- nin %	Ex- tract* Purity %	Tan- nin %	Ex- tract* Purity %	Tan- nin %	Ex- tract* Purity %	Tan- nin %	Ex- tract* Purity %	Tan- nin %	Ex- tract* Purity %	Tan- nin %	Ex- tract* Purity %
A3-203 Sacaton, Ariz.																	
1948																	
A23-1 San Carlos, Ariz.		37.5	66.2	42.3	66.2	43.4	69.0	42.7	72.3								
1948																	
A25-2 Winkelman, Ariz.		35.7	65.2	38.4	63.4	36.8	61.2			39.6	66.1	39.1	65.9				
1948																	
A25-135 Winkelman, Ariz.				32.0	58.8			36.7	66.8	34.6	67.5	36.0	68.1	37.3	63.3	36.3	64.1 good
1948																	
A26-101 Kelvin, Ariz.				36.2	61.2	37.2	61.1	39.2	62.9	39.6	64.9						
1948				36.8	61.4			40.9	70.2			41.3	73.4	42.1	72.0		low
A57-1 Sells, Ariz.																	
1953																	
SR 28 Mesa, Ariz.										36.2	68.1	36.2	68.1	38.7	67.5	37.1	67.0 high
1952										39.0	65.9						
SR 41 Mesa, Ariz.										36.4	66.6	34.9	69.3	36.6	66.2	36.8	65.1 high
1952																	
T43 1S, Self-selection								40.7	63.1	40.5	66.8	37.4	67.1	41.0	66.0		good
T43 2S, Self-selection								41.2	64.3	41.3	65.2	40.1	66.6	41.5	67.4		
												41.4	68.1	40.9	65.9		high
												42.1	73.6	40.7	72.2		
(SRXY)-7 Outcross selection										41.2	71.6			41.0	72.2		
70-17 Salt River, outcross selection																	

\*Extract Purity = Tannin/soluble extractives × 100.

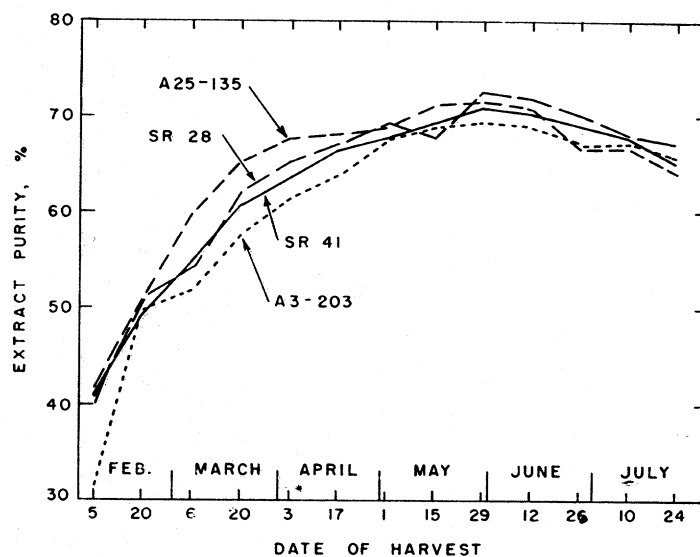


FIGURE 2.—Changes in extract purity of four varieties of canaigre throughout the growing season.

A study of the compositional changes of canaigre roots during growth indicates the period when the roots are best suited for harvest and will produce extracts of highest purity. The data presented indicate that the end of June or early July, immediately after top decline, would be the most advantageous harvesting time for processing. However, roots at this stage are soft-skinned and easily damaged. Harvesting at a later date would be preferable if roots were to be stored.

#### GERM PLASM BANK

When it became apparent that the canaigre projects might be discontinued, much thought was given to the preservation of the best canaigre varieties developed. Considerable effort and expense had gone into collecting canaigre planting stock from all parts of the natural range of the species, in developing from them pure vegetative lines and promising selections from the breeding nursery, and in testing such selections for desirable agronomic and chemical characteristics. Therefore, it was important that the best varieties be preserved for possible future use.

volume, and tannin was determined by the official methods of the American Leather Chemists Association (19). Purities have been calculated on the basis of soluble extractives.

The data obtained from these close intervals of harvest show clearly the rapid changes occurring in the growth development of canaigre. These data are shown in Table V, and the changes in tannin content and extract purity are shown graphically in Figs. 1 and 2.

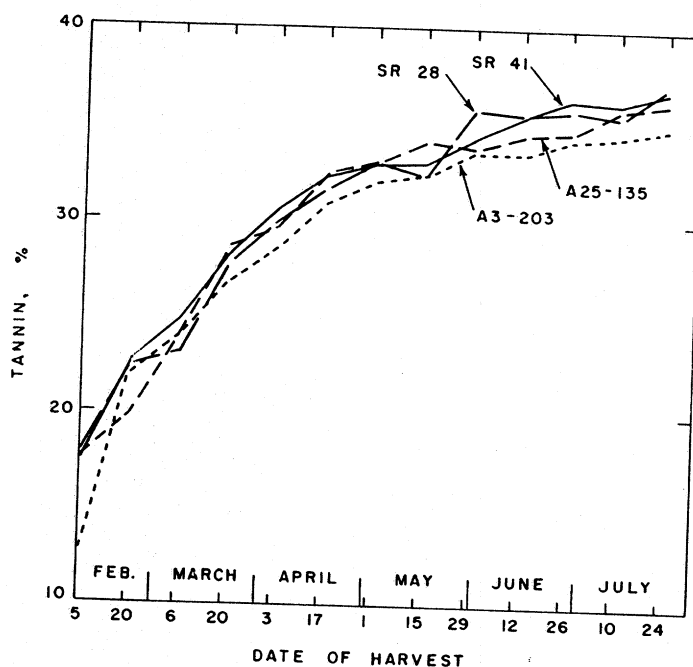


FIGURE 1.—Changes in tannin content of four varieties of canaigre throughout the growing season.

The results obtained from the 1961 harvesting bear out the trends observed from previous harvesting experiments. The most pronounced changes in root composition occurred during the period of most rapid plant and root growth. There was a steady and rapid increase in the tannin content of all four samples from early February until top decline in late May or early June. Then there was a leveling off of the tannin content with only slight increases until July 24. The extract purity of all four varieties increased quite rapidly to a maximum in late May and then decreased through June and July. The decline in extract purity and the slight increases in tannin after the end of May coincide with the dying back of the plant growth in late May or early June. The plants are dormant by early July. As this dormant period advances, the starch is gradually broken

TABLE VI

## DESCRIPTION OF MATERIAL PLANTED IN BULK AT EACH OF THREE SITES IN TONTO NATIONAL FOREST

Varities	SR 28	SR 41	A25-135	(SRXY)-7
Tannin, %*	37.1	36.8	36.3	42.1
Extract purity, %*	67.0	65.1	64.1	73.6
Yield, tons per acre	18.8	16.8	17.1	20.5
Diplodia resistance	None	None	Fair	None
Root internal color†	pk 1	pk 1	pk 1 to pk 2	pk 2, pk 3
External root character	Smooth	Smooth	Rough	Smooth, tendency to branch
Geographical origin	Mesa, Ariz.	Mesa, Ariz.	Winkelman, Ariz.	Salt River Outcross
Year collected or selected	1952	1952	1948	1957
No. feet of row planted at:				
Site 1	1025	1280	904	600
Site 2	1134	909	895	540
Site 3	1068	999	1008	600
Total	3227	3188	2807	1740

\*Tannin and purity determinations made on samples of SR 28, SR 41, and A25-135 freshly harvested and dried 7/24/61. Some previous determinations rate SR 28 as high as 39.0% and SR 41 as high as 37.0% tannin. Extract purity is tannin divided by soluble extractives times 100.

†Internal root color is indicated by symbols.

pk = pink; 0, 1, 2, 3, 4, or 5 indicate intensity of pink color of root flesh.  
y = yellow where it is a prominent flesh color in part or all of the root.  
1, 2, 3, or 4 after y indicate intensity of color.